XXXII.—*New Bryozoa from the Kuckers Stage in Esthonia.*

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[Plate VII.]

Introduction.

In the summer of 1917, I made a collection of bryozoa in the quarries of the villages Türpsalu and Kukruse or Kuckers, 10 km. N.W. of Jewe Station. These quarries had been taken in hand by the Russian Committee of Fuel in Petrograd, for the purpose of determining the existence and thickness of shale in the Kuckers stage of the Middle Ordovician in Esthonia. I was unable to obtain the results of their research, and because of war conditions could move without restriction only in a very limited area.

During the winter of 1917, and in the first quarter of 1918, I determined a part of the collection in the Geological Institute of the University of Tartu (Dorpat or Jurjev). For the more complete examination and study of my collection, I had the opportunity of visiting London.

I am indebted to the officers of the Geological Department of the British Museum for facilities in the library, for the use of Dr. R. S. Bassler's bryozoa collection from Esthonia, and the bryozoa material collected by Dr. F. A. Bather from Esthonia and the Swedish formations, especially those of Oeland.

I have also been permitted to work in the Library and Museum of Practical Geology.

Finally, I must express my warmest thanks to Dr. F. A. Bather, F.R.S., for his indispensable help in revising the manuscript.

Kuckers Stage in Kukruse and Türpsalu.

In the vicinity of the villages Kukruse and Türpsalu, 3–6 km. from the shores of the Gulf of Finland, the Middle Ordovician strata rise in a sloping terrace, varying in height from 3 to 5 or 6 metres. On the slope of this ascent the Kuckers stage (C_2 of F. Schmidt*) crops out. This stage is a white or greyish-yellow limestone or marl, with intercalated layers of bituminous shale.

* F. Schmidt, "On the Silurian and Cambrian Strata of the Baltic Provinces etc.," Quart. Journ. Geol. Soc. xxxviii. p. 514 (1882).

In a quarry on the top of the ascent in the village Türpsalu is the following section :—

Ground moraine and soil.

60 in.—Greyish limestone, marly in the lower part.
8 in.—Bituminous shale.
12 in.—Marly limestone.
16 in.—Bituminous shale.
20 in.—Compact greyish limestone, marly in the upper part.

The lowest limestone, of which only the upper 20 inches are here observed, contains abundant remains of different species of Orthoceratites, Brachiopoda, Cystoidea—among these *Echinosphærites aurantium*, Gyll.,—and other fossils. The upper part of this limestone has thin interlayers of yellow-brown shale.

On this limestone rests a shale layer, 16 in. thick, of a rusty-brown or amber colour ; the shale has absorbed a certain amount of underground water, is soft, and can be ground with the fingers. After drying the shale is lighter in colour, with different shades of light or dark brown, walnut, or amber—the lighter portions being those which contain more calcareous remains of organisms. The hardness of the shale depends on the amount of lime or clay-marl ; the hardness of the lime-shale may be 1·5–2, whilst the clay-shale is very soft (1). The dry shale can be split into irregular slates with conchoidal fracture.

According to Paltshinski ("Denj," viii. 1917), the bituminous shale occurred from Zamburg (Russia) to Reval (Esthonia)—200 km.—over an area 50 km. wide. The total quantity of the bituminous shale may be 40 to 50 milliards of tons.

Then follows a thin bed (12 in.) of greyish or light yellow marly limestone ; this limestone is interbedded with thin layers of shale from a quarter to three-quarters of an inch thick.

On this limestone again rests a bed of shale (8 in.), like that already described.

Finally, above this shale bed is a greyish limestone (60 in.) ; its lower part is marly or softer, with thin interlayers of shale ; towards the top it is more compact and greyish white.

The surface of this limestone and the slopes of the terrace are covered with a ground-moraine—boulder clay, or gravel and sand,—varying in thickness from 2 or 3 in. to 80 in. and more. The lower part of this ground-moraine is the "rühk," composed of limestone boulders.

The whole thickness of the Kuckers stage, which may vary from 30 to 50 feet, is not seen in the beds of the quarry described above.

Below the terrace bituminous shale is found under peat for a distance of 1 km. northwards. The shale was to be used in the summer 1917 for fuel in some factories in Esthonia and Petrograd. In Kukruse and Türpsalu it was worked from quarries and adits under the terrace-like ascent.

The marly bed and the limestone of the Kuckers stage contain very fine crystals of marcasite, galena, groups of calcite crystals, and copper glance.

The fauna of the Kuckers stage is very abundant: though closely related to the Echinosphærite limestone (C_1), the development of species and individuals is greater. In great abundance are brachiopods, gasteropods, crinoids, cystideans, orthoceratites, ostracods, and fragmentary remains of trilobites. The characteristic fossil *Phacops* (*Chasmops*) *ordini* can often be found in excellent preservation, as can also other fossils. The various bryozoa exist in great abundance. Very often the shale-beds are crowded with bifoliate and other fine bryozoa, whose white calcareous skeletons compose 30 to 40 per cent. of the shale in some parts.

New Bryozoa of the Kuckers Stage.

Pachydictya, Ulrich.

E. O. Ulrich, 1882, Journ. Cincinnati Soc. Nat. Hist. vol. v. p. 152.
E. O. Ulrich, 1890, "Paleozoic Bryozoa," Geol. Surv. Illinois, vol. viii. part 2.
R. S. Bassler, 1911, "Early Paleoz. Bryozoa of the Baltic Provinces," Bull. U.S. National Mus. lxxvii. p. 137.

Pachydictya kuckersensis, sp. n. (Pl. VII. figs. 1–6.)

Diagnosis. Zoarium bifoliate, frequently branching. The zoœcial apertures circular, arranged in transverse, often sinuous rows.

Locality and Horizon. Kukruse (Kuckers) and Türpsalu, Esthonia. Middle Ordovician, stage C_2 of Prof. F. Schmidt.

Material. Holotype in my collection in the Geological Museum of the University of Tartu (Dorpat). Paratypes, two specimens of my collection in the British Museum, Geological Dept., Regd. D. 29836–7.

Description. Zoarium dichotomously branching; the branches may be situated close to (1 mm.) or at any distance (21 mm. or more) from each other (figs. 1, 2, 3). The

branches on my fragment are 2 mm. broad near the stem and gradually get broader ; their normal width is 3 mm. ; the zoarium is 1–1·5 mm. thick and elliptical in transverse section.

Zoœcia are situated on both sides of the zoarium, but not on its margins. On the surface the shape of the zoœcia is circular, sometimes one end of the aperture is slightly narrower ; the zoœcial apertures have a distinct peristome. Transverse to the axis of the zoarium, within 2 mm. are 5 zoœcia. The transverse rows of zoœcia, often sinuous, vary in number from 4 to 6 within 2 mm. according to the size of the interspaces. On the face of a zoarium 3 mm. wide in a transverse row are 7–9 zoœcia. The surface of the zoarium between the zoœcial apertures and on the margins is covered with numerous minute granules (fig. 4.)

A tangential section (fig. 5) shows in the greyish calcite mass lighter, hexagonally shaped figures, with circular or oval transverse sections of zoœcial tubes, a little smaller than the zoœcial apertures on the surface of the zoarium.

A transverse section (fig. 6) shows the zoœcial tubes with thin, light-coloured, narrow walls ; in the tubes are some diaphragms ; the tubes are a little larger on the surface than in the interior of the zoarium. In the middle of the same section are two layers of median tubuli, as seen in transverse section.

Comparison with other Species of Pachydictya *in Esthonia* *. —*P. elegans* always has elliptical zoœcial apertures, with less distinct peristome ; between the longitudinal zoœcial rows are distinct ridges, and the ends of the elliptical apertures are also joined by ridges. *P. flabellum* differs from *P. elegans* and *P. kuckersensis* by its oviform zoœcial apertures, and from the latter by its ridges on the surface of the zoarium. *P. cyclostomoides* differs from all other species of *Pachydictya* in its large zoœcial apertures and in its granular ridges between the zoœcial rows. *P. crassa* differs strikingly from *P. kuckersensis* in the distinct straight ridges between the zoœcial rows and in the shape of its zoœcial apertures.

Pachydictya crassa, Hall. (Pl. VII. figs. 7, 8.)

Stictopora crassa Hall, 1852, Nat. Hist. New York, Pal. ii. p. 45, pl. xviii. figs. 4 *a–c*.

Pachydictya crassa, Hall, Bassler, 1906, "Bryozoan Fauna of the Rochester Shale," Bull. U.S. Geol. Surv. ccxcii. p. 57, pl. xviii. figs. 11, 12, pl. xxi. figs. 14–16.

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* See R. S. Bassler, 1911, "Early Paleoz. Bryozoa of the Baltic Provinces," Bull. U.S. National Mus. lxxvii.

Diagnosis. Zoarium dichotomously branching with parallel edges; branches in cross-section elliptical, with narrow, non-celluliferous, striated margins. Zoœcial apertures elliptical, in parallel longitudinal rows, separated by linear ridges, without granules.

Locality and Horizon. Kukruse, Esthonia. Middle Ordovician, stage C_2; in the bituminous shale.

Material. Figured specimen (fig. 8) in the British Museum, Geological Dept., Regd. D. 29832. Specimens in my collection in the Geological Museum of the University of Tartu (Dorpat).

Description. The fragmentary zoaria of my specimens possess zoœcia on both sides, branching dichotomously. The branches are 2–2·5 mm. wide. The length of the figured zoarial fragment (fig. 7) is 22 mm.

The zoœcial apertures are elliptical, a very few are slightly pointed. The apertures have a thin-walled peristome. Longitudinally to the axis of the zoarium, within 2 mm. are 3·5–4 apertures. The zoœcia are in longitudinal parallel rows; they are separated from each other by spaces equal to the half of their longer diameter. On each side of the zoarium are 7 or 8 rows of zoœcia (fig. 8). The zoœcial rows are separated from each other by fine linear ridges. The zoarium is elliptical in cross-section, with sharpened striated margins.

My specimens are in all respects very similar to the American specimens of *P. crassa* figured by Bassler (*loc. cit.*).

Nematopora, Ulrich.

E. O. Ulrich, 1888, Amer. Geol. vol. i. p. 234.
E. O. Ulrich, 1890, "Paleozoic Bryozoa," Geol. Surv. Illinois, vol. viii. pt. 2, pp. 401, 644.
R. S. Bassler, 1911, "Early Paleoz. Bryozoa of the Baltic Provinces," Bull. U.S. National Mus. lxxvii. p. 155.

Nematopora bogoljubovi, sp. n. (Pl. VII. figs. 9, 10.)

Diagnosis. Zoœcia surround the cylindrical zoarium in more or less parallel rows. Between the rows of the elliptical zoœcial apertures are fine canaliculate longitudinal ridges; these are divided by little transverse ridges into squares.

Locality and Horizon. Kukruse, Esthonia. Middle Ordovician, stage C_2; rare in the bituminous shale.

Material. Holotype in British Museum, Geological Dept., Regd. D. 29833. Paratype in my collection in the Geological Museum of the University of Tartu (Dorpat).

	After Bassler's records.									After my observation in Kuckers stage.
	Glauconite limestone. B_2.	Echinosphær. limestone. C_1.	Kuckers shale. C_2.	Tewe limest. D_1.	Wassalem bed. D_3.	Wesenberg limestone. E.	Lyckholm limestone. F_1.	Borkholm limestone. F_2.	Rochester shale.	
Order CYCLOSTOMATA.										
1. Stomatopora arachnoidea, *Hall*	..	..	*	..	..	..	..	..	..	×
2. Mitoclema mundulum, *Ulrich*	..	..	*							
3. Protocrisina ulrichi, *Bassler*	..	..	*	..	..	..	..	..	..	×
4. —— exigua, *Ulrich*	..	..	..	..	..	..	..	*	..	×
5. Cœloclema laciniatus, *Eichwald*	..	..	*	..	..	..	..	..	..	×
6. Anolotichia impolita, *Ulrich*	..	..	*							
7. —— sacculus, *Bassler*	..	..	*							
8. Favositella exserta, *Bassler*	..	..	*							
Order CRYPTOSTOMATA.										
9. Graptodictya bonnemai, *Bassler*	..	..	*	..	..	..	..	..	..	×
10. Rhinidictya exserta, *Eichwald*	..	..	..	..	..	*	..	..	..	×
11. Pachydictya elegans, *Ulrich*	..	..	*	..	..	..	..	..	..	×
12. —— cyclostomoides, *Eichwald*	..	..	*	..	..	..	..	..	..	×
13. —— flabellum, *Leuchtenberg*	..	..	..	..	..	*	..	..	..	×
14. —— crassa, *Hall*	..	..	..	..	..	..	..	..	*	×
15. —— kuckersensis, sp. n.	..	..	..	..	..	..	..	..	..	×
16. Helopora divaricata, *Ulrich*	..	..	*							
17. Nematopora consueta, *Bassler*	..	..	*	..	..	..	..	..	..	×
18. —— ovalis, *Ulrich*	..	..	*	..	..	..	..	..	..	×
19. —— lineata, *Billings*	..	..	..	..	..	..	..	*	..	×
20. —— bogoljubovi, sp. n.	..	..	..	..	..	..	..	..	..	×
21. Nematotrypa gracilis, *Bassler*	..	..	*	..	..	..	..	..	..	×
22. Chasmatopora furcata, *Eichwald*	..	..	*	..	..	..	..	..	..	×
23. —— tenella, *Eichwald*	..	..	..	..	..	..	..	*	..	×

24. Pseudohornea bifida, *Eichwald*	..	..	*	..	..	..	..	..	..	×
Order TREPOSTOMATA.										
25. Homotrypella instabilis, *Ulrich*	..	..	*							
26. Mesotrypa milleporacea, *Bassler*	..	..	*							
27. —— —— parva, var., *Bassler*	..	..	*							
28. Dekayella prænuntia, *Ulrich*	..	..	*	..	..	..	..	..	..	×
29. Leptotrypa hexagonalis, *Ulrich*	..	..	*							
30. Stigmatella fordii, *Nicholson*	..	..	*							
31. Constellaria varia, *Ulrich*	..	..	..	..	*	..	..	..	..	×
32. Stellipora revalensis, *Dybovsky*	..	..	*							
33. Dianulites petropolitana, *Dybovsky*	..	..	*	..	..	..	..	..	..	×
34. Eridotrypa ædilis minor, *Ulrich*	..	..	..	..	..	*	..	..	..	×
35. Lioclema vetustum, *Bassler*	..	..	*							
36. —— spineum, *Bassler*	..	..	*							
37. Lioclemella clava, *Bassler*	..	..	..	*	..	..	..	..	..	×
38. Orbipora distincta, *Eichwald*	..	..	*							
39. Esthoniopora communis, *Bassler*	..	..	*							
40. —— curvata, *Bassler*	..	..	*							
41. Trematopora kuckersiana, *Bassler*	..	..	*							
42. Batostoma mickwitzi. *Bassler*	..	..	..	..	*	..	..	..	..	×
43. —— winchelli, *Ulrich*	..	..	..	*	..	..	..	..	..	×
44. —— fertile circulare, *Ulrich*	..	*	..	..	..	..	..	..	..	×
45. —— granulosum, *Bassler*	..	..	..	*	..	..	..	..	..	×
46. Hemiphragma tenuimurale, *Ulrich*	..	..	..	..	*	..	..	..	..	×
47. —— panderi, *Dybovsky*	..	..	*	..	..	..	..	..	..	×
48. —— multiporatum, *Bassler*	..	..	*							
49. Dittopora clavæformis, *Bassler*	*	..	..	..	..	..	..	..	..	×
50. —— colliculata, *Eichwald*	..	..	*	..	..	..	..	..	..	×
51. Diplotrypa petropolitana, *Nicholson*	..	..	*	..	..	..	..	..	..	×
52. —— bicornis, *Eichwald*	..	..	*							
53. Hallopora wesenbergiana, *Dybovsky*	..	..	..	..	..	..	*	..	..	×
54. —— dumalis, *Ulrich*	..	..	*	..	..	..	..	..	..	×
55. —— dybovskyi, *Bassler*	..	..	*	..	..	..	..	..	..	×
56. —— tenuispinosa, *Bassler*	..	..	..	..	..	*	..	..	..	×
	1	1	37	3	3	4	1	3	1	37

Description. Fragment of the zoarium (fig. 9) is 8 mm. long, the diameter of the cylindrical zoarium is 1·5 mm. The zoœcial apertures are elliptical, with rather sharpened ends; the rows of the zoœcial apertures run more or less parallel to each other, around the zoarium. In all there are 12 zoœcial rows. Longitudinally, within 2 mm. are 4 zoœcial apertures; the apertures are 0·2 mm. wide. The zoœcial apertures are separated from each other by spaces equal to, or a little less than, their longer diameter. The apertures have a distinct peristome. The surface of the zoarium is sculptured; the sharpened ends of the zoœcial apertures are connected by two fine ridges; from these some transverse ridges may go to the longitudinal ridges (fig. 10). These longitudinal ridges run parallel between the rows of the zoœcial apertures; they are grooved above or canaliculate. This fine groove is divided by numerous fine transverse ridges into little squares; little apertures sometimes occur on the bottoms of these squares.

Comparison with other Species in Esthonia.—N. bogoljubovi has more numerous rows of zoœcia (13, 12), whilst *N. consueta* has only 4 rows, *N. ovalis* 4 or 5, *N. fragilis* 6, *N. lineata* 6 (or less). In addition the structure of the surface is more complicated in this species.

The trivial name is in honour of my first teacher of geology in Tartu (Jurjev), Professor N. Bogoljubov.

On the table (pp. 332 & 333) are marked with asterisks the species of bryozoa recorded by Bassler (1911, "Early Paleoz. Bryoz. Baltic Prov.") from the Kuckers stage, and the stages above or below this stage. From the Kuckers shale and limestone near Jewe and Kuckers, the district in which I collected, Bassler quotes 37 species (from the Kuckers stage, from Jewe to Reval, Bassler quotes 46 species). Of these 37 species, I have found 18 in my collection.

In the columns, with the exception of the third and two last, are species which Bassler described among others from the Glauconite, Echinosphærite, and Jewe limestones, the Wassalem bed, and the Wesenberg, Lyckholm, and Borkholm limestones. I have found these species—16—in the Kuckers shale and marl or limestone in the quarries of the villages Kukruse and Türpsalu.

In the last column are marked with (×) all the species, with two new spp. and one American, which I found in the Kuckers shale and marl or marly limestone.

The bryozoan fauna in the Kuckers stage is very rich. In a very limited locality (3 to 5 km.) I have found 37 species.

With the other species named by Bassler for this stage, this makes a total of 56 species.

In the British Museum, Geological Dept., there are of the species of my collection which I found in the Kuckers stage, named on the table (pp. 332 & 333), the following :—*Protocrisina exigua*, Ulrich, Regd. D. 29830 ; *Pachydictya bifurcata*, Hall, Regd. D. 29838 ; *Chasmatopora tenella*, Eichwald, Regd. D. 29831; *Batostoma winchelli*, Ulrich, Regd. D. 29834; *Batostoma fertile circulare*, Ulrich, Regd. D. 29835. The other species that I found in the Kuckers shale and marl, named on the table, are in my collection in the Geological Museum of the University of Tartu.

The mode of occurrence of the various species is remarkable. In some places the fine delicate white skeletons of diverse bryozoa are in great abundance ; locally they are absent from the shale. In the bituminous or oil shale the following abound :—*Chasmatopora furcata*, *Pseudohornea bifida*, *Protocrisina exigua*, *Pachydictya elegans*, *P. cyclostomoides*, *P. kuckersensis*, *Graptodictya bonnemai*. There is an abundance of Trepostomata in the shale and still more in the marl or limestone, e. g. : *Diplotrypa petropolitana*, *Dianulites petropolitana*, *Hallopora dybovskyi*, and various species of *Batostoma* and *Hemiphragma*.

EXPLANATION OF PLATE VII.

Pachydictya kuckersensis, sp. n.

Figs. 1–3. Outlines of zoarial fragments, nat. size.
Fig. 4. Portion of zoarial surface, × 12 diam.
Fig. 5. Tangential section of zoarium, × 12 diam.
Fig. 6. Transverse section of zoarium, × 12 diam.

Pachydictya crassa, Hall.

Fig. 7. Outline of zoarial fragment, Brit. Mus., Geol. Dept., D. 29832 ; nat. size.
Fig. 8. Portion of zoarial surface of the same specimen, × 7 diam.

Nematopora bogoljubovi, sp. n.

Fig. 9. Zoarial fragment ; holotype ; Brit. Mus., Geol. Dept., D. 29833 ; nat. size.
Fig. 10. Portion of zoarial surface of the holotype, × 13 diam.